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RANGE INVESTIGATIONS, BIGHORN NATIONAL FOREST, WYOMING

(Progress Report No. 1)

By

Richard M. Hurd and Neland A. Kissinger, Jr.

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION*
FOREST SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE
FORT COLLINS, COLORADO

*Maintained in cooperation with Colorado A & M College

FOREWORD

A cooperative range research program was started in 1951 on the Bighorn National Forest to obtain information to aid in the management of these and similar mountain ranges grazed by livestock. The technical phases of this research program are being handled by the University of Wyoming and the Rocky Mountain Forest and Range Experiment Station. Much of this research was made possible by the cooperation of the National Forest Administration Branch of the Forest Service, the Wyoming Natural Resource Board, and the Bighorn Permittee Association.

Portions of this research program have been reported by Lang et al (10)[1/] and Beetle (1). This progress report covers additional phases of the cooperative research program.

1/ Underlined numbers in parenthesis refer to References Cited, page 7A.

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2/ Range Conservationists, Rocky Mountain Forest and Range Experiment Station, maintained by the Forest Service, U. S. Department of Agriculture, in cooperation with Colorado A & M College at Fort Collins, Colorado, and with Research Center Headquarters at Laramie, Wyoming, in cooperation with the University of Wyoming.

INTRODUCTION

The Bighorn National Forest is located in north central Wyoming, being bounded on the north by the Montana state line (fig. 1). The Forest is entirely within the Big Horn Mountains, although this mountain range extends 40 to 50 miles south and 10 miles north of the Forest boundary. As a result, not more than an estimated two-thirds of the mountain range is within the Forest. South of the Forest, the Big Horn Mountains join the high east-west range of the Bridger and Owl Creek Mountains. North of the Forest boundary, the Big Horn Mountains end at the canyon of the Big Horn River, north of which the same uplift is continued in the Pryor Mountains, a range of moderate elevation which extends but a short distance (6). In general, the eastern edge of the Forest follows along the face of the mountains, but the western boundary often is above 8,000 feet on sedimentary formations sloping toward the Big Horn Basin.

Underlying the soil mantle and in places outcropping on the surface are both granitic and sedimentary rocks. The granites are extensively exposed in the high mountain areas where the sedimentary layers have been entirely cut away and glacial activity is clearly evident (6). The sedimentary layers consist of sandstone, limestone, shales, and loosely consolidated beds of gravel and sand (16). The oldest of these sedimentary deposits and the one lying directly on the granite is the Deadwood formation of the Cambrian system. Because of the soft shales in this formation, it has often weathered in long slopes and rounded knobs -- Bald Mountain is an example (8). Many of the treeless and brushfree openings or parks on the Medicine Wheel and Tongue Districts (fig. 2) occur on this formation. Sedimentary formations are particularly common on the Tongue, Medicine Wheel, and Paintrock Districts. The other three districts (fig. 1) are characterized for the most part by exposed red and gray granites and soil derived from this parent material. On the Buffalo District, in particular, are found extensive brushfree parks on preglacial deposits of granitic debris (6).

Black acid Prairie soils have been developed under the grass-forb (weed) cover, while Podzolic soils are associated with the coniferous forests (16). Both soil groups have granitic and sedimentary rocks as parent material. Under similar conditions, however, grassland soils developed from the sedimentary rocks are deeper, darker, and more productive than the soils developed from granitic rocks. Where topography is favorable, soils from the Deadwood formation are relatively deep, having 12 to 14 inches of friable silt loam underlain by a layer of clay loam often of similar thickness. Beneath this a heavy plastic yellow clay is commonly found. On steep slopes the sedimentary soils are shallower and 3 to 8 inches of brown or yellow-brown soil may lie directly upon parent limestone (16). Generally the grassland granitic soils are shallower and appear to dry more quickly than sedimentary soils.

A humid or subhumid climate prevails over the Big Horn Mountains where the precipitation greatly exceeds that of the plains to east and west. In addition, the lower temperatures in the mountains check the evaporation and increase the humidity thereby prolonging the season of growth. A somewhat less humid belt follows the base of the mountains and in turn this gives way to the semiarid climate of the plains (16). The seasonal variation in temperature on the plains is much greater and extremes of heat and cold are also greater than in the mountains. The mean temperature in the mountains, however, is much lower than on the plains (see Climate, Appendix) and frost and snow storms may occur at any time. The accumulation of snow at the higher elevations is instrumental in the

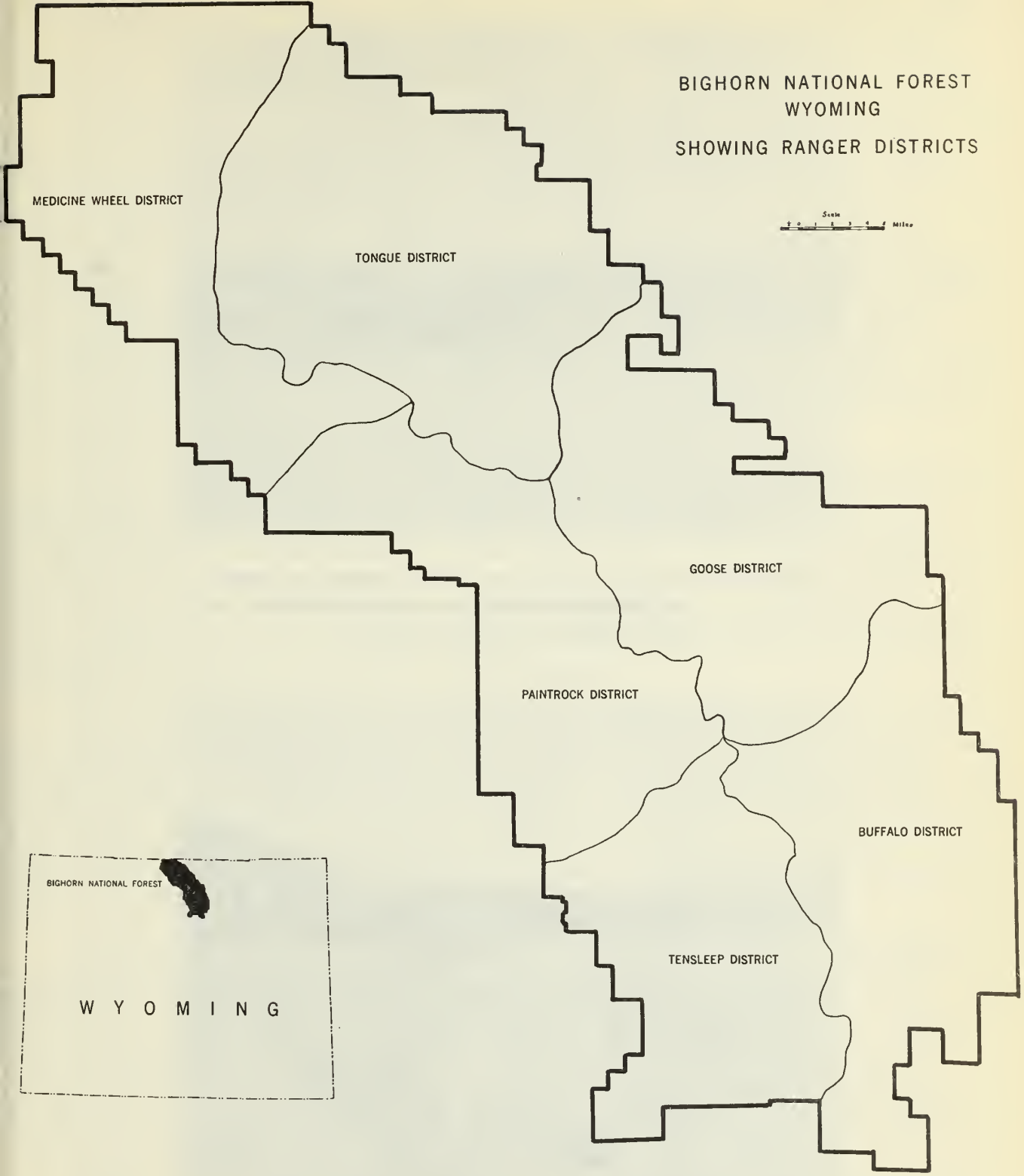
BIGHORN NATIONAL FOREST
WYOMING
SHOWING RANGER DISTRICTS
MEDICINE WHEEL DISTRICT
TONGUE DISTRICT
GOOSE DISTRICT
PAINTROCK DISTRICT
BUFFALO DISTRICT
TENSLEEP DISTRICT
BIGHORN NATIONAL FOREST
WYOMING

Figure 1

Figure 2.--Large openings or parks rimmed by stands of lodgepole pine are characteristic of the Bighorn National Forest.

Figure 3.--A mixture of grasses, sedges, and forbs growing with an open stand of shrubby cinquefoil. This is a drier phase of the bottom-type vegetation but more moist than the adjacent upland sites having granitic soils.

continuance of the flow of streams heading in the National Forest. Also, rainstorms originating in the mountains during the spring and summer contribute to the flow. As the storms drift eastward they add considerable moisture to the lands at the base of the mountains (16).

Vegetation on the Forest is generally sharply divided between trees and herbaceous cover (fig. 2). As a result there are many large openings or parks which are treeless and covered by a variety of grasses, sedges, and forbs. The variety and profuseness of the forbs, particularly on the deeper sedimentary soils, create a changing color as the season progresses from the bright yellow of the early blooming buttercup to the dark blue of September flowering aster. Growing with the forbs is Idaho fescue, the most frequent and most abundant grass on the Forest. Associated with it are a number of other grasses of which the bluegrasses, wheatgrasses, and sedges are the most common. On the granitic soils where the forbs are less abundant, Idaho fescue, Sandberg bluegrass, and sedges are prominent in the vegetative cover. This herbaceous cover becomes sparse within the dense stands of lodgepole pine, Engelmann spruce, and alpine fir. Here the forest floor is commonly covered by huckleberry and occasional grasses and forbs growing out of a mat of needles.

Along the streams and in poorly drained areas are often found dense fields of shrubby willows. Growing here also are tufted hairgrass, bluegrasses, and various sedges, as well as moisture-loving forbs. Open stands of shrubby cinquefoil appear locally -- often between the wet mucky soils of the typical bottom sites and the well-drained upland sites (fig. 3). On the upland soils, particularly the drier south and west slopes having sedimentary soils, big sagebrush occurs. This shrub forms uniformly open to moderately thick stands with a variety of forbs and grasses in the understory. Many of the parks and openings are brush-free except for shrubby willows along the drainages.

The increased precipitation, lower summer temperatures, productive soils, and succulent and nutritious plants common to these outlying mountains favored their use as summer livestock range. Livestock growers have prized such ranges because they produced grass-fat cattle and lambs. In the early days sheep were the principal livestock to use the Forest ranges and in 1900, 205,000 head were grazed on these ranges in addition to 4,900 head of cattle (9). In 1951, 27,360 cattle and 71,860 sheep grazed on approximately half of the 1,100,000 acres within the Forest boundary.

The pattern of grazing use is typical of most mountain areas surrounded by the more arid lands at the lower elevations. As the forage plants on the lower ranges become dry in late spring and early summer, the livestock move to higher elevations -- the summer range -- where vegetation is succulent and nutritious. With the coming of fall storms in September and October, the livestock are moved to the lower elevations. The arid winter ranges are then grazed as are those near the home ranch where hay grown on the irrigated lands is fed. The lower and foothill ranges are grazed in the spring after which the livestock again move to the mountains for summer grazing.

Because livestock grazing is an important use on the National Forest along with recreation use, timber and water production, and use by wildlife, a research program was started. The purpose of this research was to provide information useful to the management of these and similar mountain ranges. To accomplish this, there was need to obtain basic information about the ranges themselves in order to provide a foundation on which to build. The work in 1951 was undertaken with that in mind.

OBJECTIVES

Work during the field season of 1951 was directed principally to obtaining information on (1) plant composition, (2) herbage production, (3) preference of livestock for various species, and (4) plant growth and development.

LOCATION

For the most part, the work was located in the sagebrush-free parks or openings of the cattle range between 7,200 to 8,500 feet elevation on the Tongue and Buffalo Districts of the Forest. Usually work areas were selected because they represented the type of cattle range being investigated and were readily accessible. Transects and plots within an area were ordinarily randomly located within various distances from water; in some instances steepness of slope also restricted random location.

Greatest effort was directed to obtain information on the upland vegetative type rather than the bottom type, usually wet meadows, because of the greater area of the former. However, the bottom type, although limited in acreage, appears to be an important forage-producing area (fig. 3). This seemed to be particularly true on the Buffalo District and probably other places where upland vegetation is growing on the more droughty-appearing soils of granitic origin.

Plots and transects used to obtain detailed information on the Buffalo District were located with but few exceptions on the soils derived from granitic material, whereas on the Tongue District many of the parks and openings have soils derived from sedimentary rocks. Consequently the research was concentrated on these sedimentary soils although a few plots did occur on soils from granite outcrops along the North Tongue River. On both Districts, supplemental information was obtained from plots in the bottom-type vegetation where the soils, although variable, are characteristically poorly drained and have a thick black mucky top layer lying on gravels, sands, and clays.

Investigations on sheep range were more limited and included plant-development stations at 9,300 and 9,500 feet elevation. Temporary transects also were used to obtain species preference and herbage production at four sites on three sheep allotments occurring on the Medicine Wheel, Paintrock, and Tongue Districts.

METHODS

Composition, herbage production, and preference data were obtained by using either temporary or permanent transects 500 feet long with 10 equally spaced plots along the transect. Size of plot (sampling unit) varied with the type of information desired; for example, on cattle ranges a square 3.1-foot plot (9.6 square feet) was used for production and composition, a circular 25 square-foot plot was used to obtain species preference and utilization, and a circular 0.01-acre plot to estimate use by game.

Composition was estimated by the square-foot density method (point-observation plot) described by Stewart and Hutchings (15). Density was visualized as crown density (vertical projection) and expressed as percent ground cover in this report. Those species accounting for less than approximately 2 percent of the ground cover for any plot were usually lumped as "other grasses" or "other forbs" depending upon the kind of vegetation.

Herbage production was obtained by the weight-estimate method essentially as reported by Pechanec and Pickford (13). The production for all species accounting for approximately 2 percent or more of the composition was estimated to the nearest 5 grams for any plot. Green-weight samples were ordinarily taken to obtain air-dry weights and when this was not done, available samples for species having similar growth form and greenness were used. The convenience in estimating weight in grams for a plot containing 9.6 square feet and converting to pounds per acre by multiplying grams by 10 has been discussed by others (2,8).

Preference shown by livestock for various species was obtained through utilization estimates in the manner described by Pechanec and Pickford (12) as the ocular estimate-by-plot method. This method is based on the estimated weight removed from a species by grazing animals and expressed as a percent of the total weight of the plant's herbage or that of the herbage on the plot being observed. A circular 25 square-foot plot was used to obtain this information on the cattle range, while a square-foot plot was used to obtain this and other information on sheep range.

Pellet-group-count method (11) was used to obtain deer and elk use on some of the cattle range of the Buffalo District. Circular 0.01-acre plots were superimposed on the permanent transect plots used to obtain forage-utilization estimates. Pellet-group counts were made in July and again at the time cattle went off the ranges in September. Difference in number of groups on the plots gives an index of deer and elk days' use occurring simultaneously with livestock grazing.

Plant growth and development information was obtained at six locations or stations consisting of a 50 x 100-foot fenced exclosure built on range grazed the previous season (1950). All such stations had a southeastern to southern exposure and were located on slopes of 5 to 15 percent. The two stations on the Buffalo District were on granitic soils at approximately 7,200 and 8,000 feet elevation. Both of those on the Tongue District were on sedimentary soils (Deadwood formation) at 8,000 and 8,500 feet. The 9,300-foot station was on the granite soil of the Paintrock District, whereas the 9,500-foot location was on sedimentary soils (Deadwood formation) on the Medicine Wheel District. The two highest stations are approximately on the main divide of the Big Horn Mountains, while the other four stations are on the east slope. Rain gages were set up at each location and precipitation measured at 2-week intervals or oftener.

Within each exclosure, several species were selected for detailed observation and measurement. At each exclosure, 10 plots, each 1 square foot, were selected for each of the species to be measured; usually a square-foot plot contained one to as many as five plants of the desired grass or sedge. At 2-week intervals, the maximum height (usually flower stalk) for each plot was measured to the nearest 0.1 inch. The average for the 10 plots gave the average maximum height for such species. In addition, similar measurements were made for the basal leaves of Idaho fescue, a species present at all six stations. Herbage production was also estimated on each of the 10 plots for the measured species. Stage of development was recorded for each species at the time measurements were made. Similar information was recorded for many of the associated grasses and forbs occurring within the exclosure but which were not measured.

Identifications of some of the species mentioned in this report are tentative, while others have been identified by Dr. C. L. Porter, Curator, Rocky Mountain Herbarium, and are deposited at that herbarium on the campus of the University of Wyoming. Appreciation is expressed to Dr. Porter for his help.

Table 1 summarizes the kind of data collected during the 1951 field season as well as the general location and description of the work areas.

Table 1.--Kind of data collected on upland sites at six areas on the Bighorn National Forest, 1951

Item	Areas and kind of data collected					
Elevation (feet)	7,200	8,000	8,000	8,500	9,300	9,500
Soil (parent material)	Granitic	Granitic	Sed.1/	Sed.	Granitic	Sed.
District	Buffalo	Buffalo	Tongue	Tongue	Paint-rock	Medicine Wheel
Plant development	x	x	x	x	x	x
Composition 2/	x	x	x	x	--	--
Production	x	x	x	x	x	x
Species preference - cattle3/	x	x	x	--	--	--
Species preference - sheep	--	--	--	--	x	x
Game use	x	x	--	--	--	--

1/ Sedimentary
2/ Based on percent of ground cover
3/ Includes limited data for bottom sites

RESULTS

The collection of composition and production information was timed to coincide as much as possible with the period of maximum development of the grasses. By this time some of the early blooming forbs had dried and disintegrated. As a result, these species did not appear in the composition lists nor did they contribute to the total herbage production of the forbs. As a consequence, the production and composition of the forbs are probably underestimated while similar data for the grasses are thought to be closer to actual conditions.

For brevity, the names "Tongue District" and Buffalo District" will be used frequently in tables and text. These names here have a restricted meaning since they refer to the areas where the work was concentrated rather than the entire district.

Composition and production

The herbaceous vegetation on the cattle range of the Buffalo and Tongue Districts is characterized by perennial plants. When annuals were found, they were confined to disturbed soil such as recent (1- or 2-year-old) pocket gopher mounds, along some roads, stock concentration areas -- salt grounds, water tanks, corrals -- and cabins. The annuals were largely forbs, with littleflower collinsia and slenderleaf gilia probably the most common and at the same time, insignificant. On none of the transects did annual vegetation average as much as 1 percent of the ground cover nor produce as much as 1 pound per acre of herbage.

Idaho fescue is the grass that characterizes the upland type perennial herbaceous vegetation of these cattle ranges. It occurred on 95 percent of the

Table 2.--Ground cover, vegetative cover, herbage production (pounds per acre, air-dry), and frequency on sedimentary and granitic soils on cattle ranges.

Species	Sedimentary soils (Tongue District)				Granitic soils (Buffalo District)[1]			
	Ground cover	Veg.[2] cover	Herb.[3] prod.	Frequency	Ground cover	Veg.[2] cover	Herb.[3] prod.	Frequency
	%	%	Lbs./A.	%	%	%	Lbs./A.	%
GRASS AND GRASSLIKE:								
Idaho fescue	7.8	10.0	108	92	10.2	16.1	196	98
Needleleaf sedge	6.1	7.8	50	81	6.0	9.4	68	94
Wheatgrasses	2.8	3.6	37	—	1.0	1.6	17	—
Big bluegrass	2.1	2.7	42	51	0.1	0.2	3	3
Sandberg bluegrass	1.1	1.4	18	31	3.6	5.7	37	81
Bluegrasses (all others)	1.2	1.5	16	—	0.5	0.8	5	—
Needlegrasses	0.6	0.8	9	—	1.2	1.9	13	—
Prairie junegrass	0.4	0.5	5	12	1.3	2.0	15	84
Timber oatgrass	0.2	0.3	6	6	0.6	0.9	8	14
Other	4.0	5.2	58	—	3.5	5.5	51	—
Total	26.4	33.8	349	—	28.0	44.1	413	—
FORBS:								
Prairiesmoke sieversia	12.6	16.1	178	73	4.3	6.8	49	64
Silky lupine	6.8	8.8	210	89	2.6	4.1	54	55
Starry cerastium	4.0	5.1	46	74	3.1	4.9	17	84
Common dandelion	3.8	4.9	25	46	0.3	0.5	2	6
Yarrow	3.6	4.6	51	73	1.0	1.6	16	22
Mountain dandelion	3.0	3.8	25	64	0.2	0.3	2	10
Hoods phlox	2.1	2.7	13	35	1.2	1.9	6	46
Northern bedstraw	1.8	2.3	16	42	0.2	0.3	2	4
Hoary balsamroot	1.1	1.4	43	20	0.3	0.5	2	12
Flowery phlox	1.1	1.4	13	25	0.2	0.3	2	5
Sticky geranium	1.0	1.3	32	18	---	---	---	---
Blueleaf cinquefoil	1.0	1.3	10	30	0.4	0.6	6	30
Ballhead sandwort	0.3	0.4	3	8	0.8	1.3	4	70
Pussytoes	0.2	0.3	3	8	3.4	5.3	44	56
Hairy goldaster	---	---	--	—	0.7	1.1	19	18
Other perennial forbs	9.1	13.0	136	—	6.5	10.2	76	—
Total	51.5	65.7	804	—	25.2	39.0	301	—
Little club moss	---	---	---	--	7.1	11.2	--	56
SHRUBS:								
Fringed sagebrush	0.3	0.4	3	—	2.4	3.7	30	40
Other	0.1	0.1	1	—	0.8	1.3	11	11
Total	0.4	0.5	4	—	3.2	5.0	41	—
Total vegetation	78.3	100.0	1,157	—	63.5	100.0	755	—
OTHER COVER:								
Litter	20.9	---	---	--	31.2	---	--	--
Bare ground	0.8	---	---	18	5.0	---	--	53
Rock	---	---	---	—	0.3	---	--	3
Total	21.7	---	---	—	36.5	---	--	--
TOTAL	100.0	---	---	--	100.0	---	--	--

1/ Some sample plots fell on granitic soil on the Tongue District and have been included with those on the Buffalo District.
2/ Vegetative cover.
3/ Herbage production.

plots and accounted for 13 percent of the vegetative cover, 33 percent of the grass cover, and 49 percent (152 pounds per acre) of the grass3/ production. In a more extensive survey, Beetle (1) found that Idaho fescue had a greater frequency (consistency of occurrence) and provided a greater amount of ground cover than any other grass on sheep range as well as cattle range. Needleleaf sedge almost equalled Idaho fescue in frequency, was slightly below it in percent of ground cover, and produced only a third as much herbage per acre. The small stature and open sodlike habit of growth of this sedge makes it relatively inconspicuous in a casual glance at the vegetation. It was found to be of more importance as ground cover than as a forage producer on these cattle ranges.

No one forb was found to be of major importance with respect to frequency, composition, and production comparable to Idaho fescue among the grasses. Starry cerastium did occur with greater consistency than did any other forb. This plant accounts for about 5 percent of the total vegetative cover, 9 percent of forb cover, and produced 6 percent of the forb herbage. However, starry cerastium was found to be unimportant as a forage plant.

Although there are similarities in the upland vegetation occurring on the granitic and sedimentary soils of the cattle ranges, the differences are perhaps more apparent. Particularly noticeable is the occurrence and herbage production of the forbs as a class and of some of the grasses. Table 2 contains the more important species, based on percent ground cover, percent of the total vegetation, frequency and amount of herbage produced, found on the granitic soils of the Buffalo District and the sedimentary soils of the Tongue District. The total grass cover on the two soils is about the same although production is greater on the granitic soils of the Buffalo District. This is due largely to the greater herbage produced by Idaho fescue which also has a greater density (percent of ground cover) on these soils.

Forbs as a group differ markedly in density and herbage production between the granitic and sedimentary soils. Where on the sedimentary soils of the Tongue District, forbs accounted for about 51.5 percent of the ground cover and produced 804 pounds air-dry herbage per acre, they produced 301 pounds on the Buffalo District and accounted for 25.2 percent of the ground cover (figs. 4 and 5). The shrubs were a relatively insignificant part of the vegetation on these particular areas. They accounted for less than 1 percent of the cover on the Tongue District and but 3.2 percent on the Buffalo District where fringed sagebrush is the major shrub species.

More vegetation and greater production per plant are undoubtedly responsible for the larger amount of herbage produced on the sedimentary soils. Total production was approximately 400 pounds more on these soils than those of granitic origin. Whether difference in the productivity of these soils is due to grazing use, fertility, or water-holding capacity is not known. Observation suggests that the granitic soils are drier or more droughty than the sedimentary soils even where precipitation is the same. Lower fertility, often associated with soils of granitic origin (14) may also influence total production by the herbaceous vegetation.

3/ Unless stated otherwise, "grass" includes sedges also.

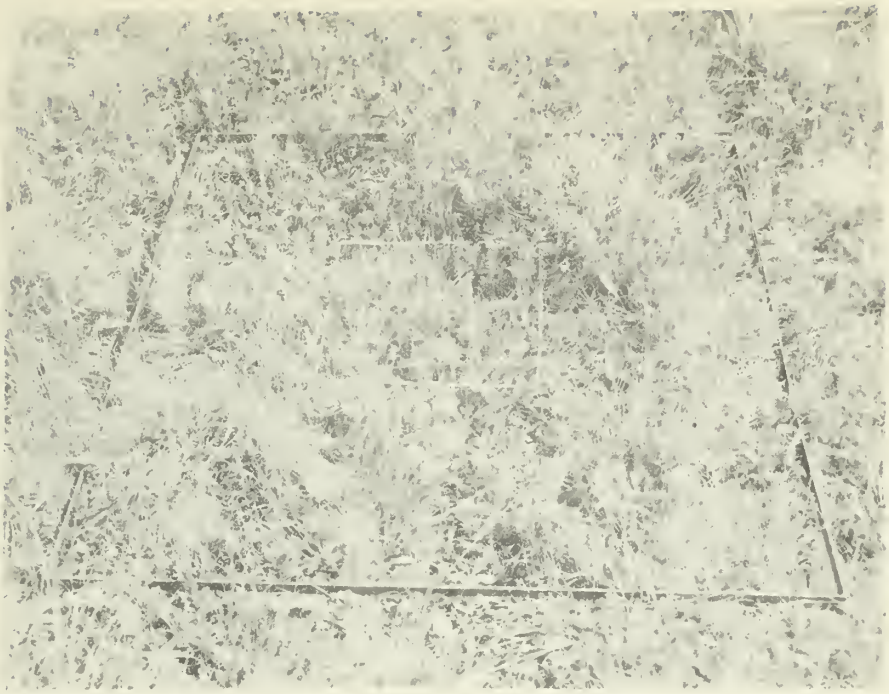

Figure 4.--Forbs were more abundant and produced more herbage on the sedimentary soils. Prairie-smoke sieversia and silky lupine were the two most common forbs.

Figure 5.--On the granitic soils, forbs were fewer, and the grasses, Idaho fescue in particular, were more conspicuous.

The frequency, abundance, and production of some species suggests strong association with the type of soil. Big bluegrass (table 2), for example, occurred on only 3 percent of the plots on granitic soils compared to 51 percent for the sedimentary soils. In contrast, Sandberg bluegrass occurred on 80 percent of the granitic plots and only 30 percent of the sedimentary plots. Similar reactions were found for pussytoes among the forbs, and for little club moss.

Grasses and grasslike plants produce 30 percent of the total herbage on the sedimentary soils compared to 55 percent on the granitic. This class of vegetation, as will be shown in a later section, provided most of the forage for the cattle and therefore is especially important as range vegetation. Of the grasses and sedges, two species, Idaho fescue and big bluegrass, account for 43 percent of the grass herbage produced on the sedimentary soils. By adding the wheatgrasses, largely slender and thickspike, the production increases to 54 percent. On the granitic soils, Idaho fescue and Sandberg bluegrass account for 57 percent of the total grass production. Here wheatgrasses were less important as forage producers. Although needleleaf sedge produced more pounds of herbage than did either big or Sandberg bluegrasses, it proved to be of minor importance as a forage plant.

Three forbs produced approximately half or more of the total forb production. On the sedimentary soils, prairiesmoke sieversia, silky lupine, and starry cerastium accounted for 54 percent of the production; substituting pussytoes for starry cerastium, the three species provided 49 percent of the forb production on the granitic soils. As determined by the amount of the herbage eaten by cattle, all of these forbs proved to be unimportant as forage.

To obtain more information on the relationship of forbs to grass, particularly on some of the sedimentary soils of the Tongue District, the vegetation in lightly grazed and protected areas was sampled. These areas consisted of two special-use pastures receiving light grazing by cattle and horses, a half-acre exclosure protected from livestock grazing since 1939, and one 200-acre area reported to have never been grazed by livestock. Sampling procedures and plot size were the same as those used to obtain composition and production information on the grazed range. This information has been averaged and is presented in table 3 along with that from the sedimentary soils part of table 2. Various exposures and soil depths are represented in both situations.

This table shows that the total vegetative cover is the same for both the grazed and protected range. Litter is essentially the same in both instances and only minor and insignificant differences occur for percent of rock and bare ground present. The most apparent change has occurred between the grass and forb classes; grasses account for 10 percent more of the ground cover on the protected ranges and at the expense of the forbs. The increase in grass and probably greater vigor has resulted in an additional 450 pounds per acre being produced. The 10-percent decrease in the forb ground cover did not materially decrease forb production. As a result, the total production is about 425 pounds greater on protected range, due largely to the presence of two grasses. Pumpelly brome and spike fescue on the protected range make up 31 percent of the grass ground cover and produce 43 percent of the grass yield (fig. 6). Of these two grasses the brome is more important as determined by percent ground cover and herbage production. These two grasses produce less than 3 percent of the grass yield on the grazed range and account for less than 1 percent of the grass ground cover. Idaho fescue makes up the same percent of ground cover (7.8 and 7.9) in both situations but produced 180 pounds on the protected range compared to 108 pounds on the grazed range due, undoubtedly, to greater vigor.

Figure 6.--Pumpelly brome, when present on the sedimentary soils of lightly grazed and protected areas, was a substantial herbage producer.

Figure 7.--Plant-development station at 7,200 feet on the granitic soils of the Buffalo District. Idaho fescue is the dominant grass, while silky lupine is the prominent forb; scattered ponderosa pine is in the background.

Table 3.--Comparison of grazed and protected[1] range areas on sedimentary soils of the Tongue District

	Protected area		Grazed area	
	Ground cover	Production[2]	Ground cover	Production[2]
	Percent	Lbs./A.	Percent	Lbs./A.
Vegetation				
Grasses and sedges	35.9	800	26.4	349
Forbs	41.7	779	51.5	804
Little club moss	0.4	---	----	---
Shrubs	0.2	3	0.4	4
Total	78.2	1,582	78.3	1,157
Litter	20.0	-----	20.9	-----
Rock	0.4	-----	----	-----
Bare ground	1.4	-----	0.8	-----
TOTAL	100.0	1,582	100.0	1,157

1/ Includes lightly grazed special-use pastures; all areas open to grazing by deer and elk.
2/ Pounds per acre, air-dry.

A similar comparison for the granitic soils of the Buffalo District is given in table 4. Here, however, the protected range is not as well represented as on the Tongue District and there is some question yet as to the representativeness of protected range to the general grazed range. Even so, this information appears useful to indicate production potentialities of these granitic soils.

Table 4.--Comparison of grazed and protected[1] range areas on granitic soils of the Buffalo District

	Protected area		Grazed area	
	Ground cover	Production[2]	Ground cover	Production[2]
	Percent	Lbs./A.	Percent	Lbs./A.
Vegetation				
Grasses and sedges	36.4	691	28.0	413
Forbs	26.4	306	20.1	301
Little club moss	8.5	---	11.2	---
Shrubs	1.6	22	3.2	41
Total	72.9	1,019	63.5	755
Litter	24.0	-----	31.2	---
Rock	----	-----	0.3	---
Bare ground	3.1	-----	5.0	---
TOTAL	100.0	1,019	100.0	755

1/ Includes a lightly grazed area as well as an area protected from livestock grazing; all areas are open to grazing by deer and elk.
2/ Pounds per acre, air-dry.

Total vegetative ground cover averaged approximately 10 percent greater for the two protected areas and total herbage production averaged 260 pounds greater. The smaller amount of live vegetative cover on the grazed range resulted in an apparent increase in litter. Actually, litter production measured in pounds per acre probably was greater on the protected range, but here live vegetation covered more of the ground surface.

A greater cover of grass on the protected plots, plus greater vigor undoubtedly accounted for the 280-pound increase in grass production. Forb cover as well as little club moss was somewhat less on the grazed range. Difference in shrub cover and production is due almost solely to the greater amount of the low-value fringed sagebrush on the grazed cattle range.

Essentially the same grasses were present on the protected plots as on the grazed plots. The principal difference in total grass yield can be attributed largely to Idaho fescue. This grass produced an average of about 500 pounds of herbage per acre on the protected plots and 200 pounds on the grazed plots; somewhat greater yield of needleleaf sedge occurred on the grazed range.

Preference and use

To determine which species were preferred by grazing animals, estimates were made on the weight of herbage removed from each species on the sample plot (12). For example, if on a transect, one species was used 50 percent and another only 10 percent, the first would be considered to be preferred by the livestock, assuming both species had equal opportunity of being eaten. Some species may account for only a very minor part of the vegetation and occur infrequently. Such a species, although having a high preference, may be of little importance as a forage plant because it is relatively insignificant in the composition and production of the range vegetation. Therefore, preference is best used in combination with composition and production to indicate the importance of a species as a producer of forage.

Cattle: As a class, grass and grasslike vegetation was preferred to forbs and furnished by far the major portion of the forage eaten by cattle. In some instances, preference-and-use information was obtained both at the middle and at the end of the grazing season primarily to learn whether there was any shift in preference for a particular species. For the most part, there was no material change in preference as the grazing season advanced although on the granitic soils of the Buffalo District, Idaho fescue did assume a higher preference ranking as the season progressed. This came about by a lower ranking for early maturing grasses, one of which was spike fescue.

As seen in table 5, some grasses of minor importance as herbage producers in the upland vegetation, were preferred by cattle. This was illustrated by timber oatgrass, spike fescue, Kentucky bluegrass, and pumpelly brome, all of which occurred infrequently and individually produced only 2 percent or less of the total grass production. In contrast, needleleaf sedge ranked second in herbage production among the grass and grasslike plants on both the sedimentary and granitic soils, but ranked lowest in preference. Idaho fescue and Sandberg and big bluegrasses not only ranked high in preference but when combined accounted for 48 and 56 percent of the total grass production on the sedimentary and granitic soils, respectively.

Table 5.--Preference, frequency, and percent of total grass production of some upland grasses on cattle ranges

Species	Sedimentary soils (Tongue District)			Granitic soils (Buffalo District)		
	Preference: Ranking	Frequency: Percent	Production: Percent	Preference: Ranking	Frequency: Percent	Production: Percent
Timber oatgrass	1/ 1	6	2	10	14	2
Spike fescue	2	1	2	6	8	Trace
Idaho fescue	3	92	31	3	98	47
Sandberg bluegrass	4	31	5	5	81	9
Big bluegrass	5	51	12	2/	--	--
Kentucky bluegrass	6	2	Trace	1	2	1
Pumpelly brome	7	9	1	2/	--	--
Needle-and-thread	2/	--	--	2	12	2
Slender wheatgrass	12	36	6	4	6	1
Bluebunch wheatgrass	2/	--	--	8	16	1
Prairie junegrass	15	12	1	9	84	4
Needleleaf sedge	17(last)	81	14	11(last)	94	16
Total			74			83

1/ Although use of timber oatgrass averaged higher than other grasses on the Tongue District, Idaho fescue always received greater use when they occurred together; similarly, when big and Sandberg bluegrasses grew with timber oatgrass they generally were preferred.

2/ Not present on transects.

Some forbs were grazed and this use was more readily seen at the middle of the grazing season than at the end. Many forbs became dry and began to disintegrate before the end of the grazing season; others dried quickly after a sharp freeze. Both of these conditions tended to obscure any use they may have received. On both the Tongue and Buffalo Districts, wild onions, mountain dandelion, mariposa lily, prairie milkvetch, and bluebell were the most preferred. Except for mountain dandelion, these forbs were minor components of the forb class. The more abundant forbs and those contributing most to forb production such as prairiesmoke sieversia, silky lupine, starry cerastium, pussytoes, and hairy goldaster (table 2) were usually either not grazed or grazed only very lightly. No attempt was made to differentiate between game and cattle use.

Information on the preference of species growing in the bottoms (along streams and poorly drained areas) is more limited. Because of the changes in growing conditions here, particularly greater moisture, tufted hairgrass, Idaho bentgrass, alpine timothy, rush, and various sedges appear. Also Kentucky bluegrass occurs more frequently than on the upland sites. Of these species, tufted hairgrass and Kentucky bluegrass were about equal in preference and were followed by Idaho bentgrass, sedges, alpine timothy, and rush. Big bluegrass and pumpelly brome also ranked high where they occurred on the Tongue District. On the Buffalo District, willow ranked high in preference and on both Districts, cattle were seen browsing willows throughout the grazing season. In one instance, after a 4- to 5-inch snowfall in September, cattle were seen browsing willows to the exclusion of the snow-covered herbaceous vegetation. Deer also were observed to browse willows throughout the livestock grazing season. Occasionally cattle were seen browsing shrubby cinquefoil, but use was absent or very light on the few plots where it occurred.

When preference and herbage production are considered together, the value of a species as a forage producer becomes more apparent. This is shown in table 6. Although many species were found in the upland vegetation, only two or three plus the wheatgrasses (thickspike, slender, bearded, and bluebunch) contributed materially to the diet of the cattle. Those species having high preference but low production such as spike fescue and Kentucky bluegrass (table 5) supply only a small amount of forage. Also of minor importance with respect to amount of feed furnished were needleleaf sedge and some of the forbs; in both instances, the species were high in production but low in preference.

Table 6.--Principal forage-producing species in the upland vegetative type on the sedimentary and granitic soils, cattle range

Species	Sedimentary soils (Tongue District)		Granitic soils (Buffalo District)	
	Rank as forage producer	Forage contributed	Rank as forage producer	Forage contributed
		Percent		Percent
Idaho fescue	1	50	1	77
Big bluegrass	2	15	1/	--
Sandberg bluegrass	3	8	2	8
Wheatgrasses (all)	4	7	3	4
Total		80		89

1/ Not present on transects.

Utilization of the principal forage species varied considerably on the same allotment even though such things as distance from water and steepness of slope were comparable. For example, in one area the average utilization for Idaho fescue was 56 percent and for Sandberg bluegrass, 48 percent, based on three transects between 500 and 2,500 feet from water. At another area on the same cattle allotment the average use on three comparable transects was 9 percent for Idaho fescue and 2 percent for Sandberg bluegrass. Utilization of the bottom-type vegetation was ordinarily considerably greater than of the typical upland grasses. The abundance of soil moisture undoubtedly is largely responsible for the species occurring in the bottoms to remain green and succulent throughout the grazing season. There appeared to be no strong relationship between distance from water (500 to 3,000 feet) and average utilization of Idaho fescue, and Sandberg and big bluegrasses. The maximum distance from water for any transect was approximately one-half mile and often could not be exceeded because of the proximity of other water.

Sheep: Preference-and-use information for the vegetation on sheep range was obtained at four sites on three sheep allotments. At all four sites the data were collected within a day or two of August 1 and since no subsequent information was obtained, any shifts in use among the species was not determined. The preference, frequency, and percent a species contributed to the total herbage production is given in table 7.

Of these preferred species, those producing the most herbage and occurring most frequently are of particular importance since they contribute more to the sheep's diet. Of the ten preferred species on the granitic soils, there are five forbs, two sedges, two grasses, and one woodrush, while on the sedimentary soils, seven are forbs, two are grasses, and one a sedge. Although forbs were usually the preferred class of vegetation, both grasses and sedges were also grazed by

Table 7.--Preference ranking, frequency, and percent of total herbage production for some species occurring on sheep ranges having sedimentary and granitic soils

Granitic soils			Sedimentary soils		
Species (listed in descending order of preference)	Total production	Frequency	Species (listed in descending order of preference)	Total production	Frequency
	%	%		%	%
1. Mountain dandelion	3	30	Orange arnica	4	55
2. Hepburn's sedge	2	26	Lambstongue groundsel	1	12
3. Aster	2	18	Sandberg bluegrass	2	38
4. Ross sedge	4	52	Mountain dandelion	1	32
5. Orange arnica	3	23	Slender wheatgrass	4	52
6. Sandberg bluegrass	5	74	Needleleaf sedge	5	52
7. Timber oatgrass	2	35	Yarrow	4	65
8. Yarrow	2	35	Blueleaf cinquefoil	3	35
9. Prairiesmoke sieversia	8	54	Alpine forget-me-not	2	35
10. Spike woodrush	3	54	Prairiesmoke sieversia	17	65
Total	34			43	

sheep. Also, regardless of the type of soil and associated vegetation, some species such as orange arnica, mountain dandelion, Sandberg bluegrass, and sedges were preferred by sheep. Some species are listed as being preferred on one kind of soil and not on the other; this usually means they did not occur in the sample plots on both soils and does not necessarily indicate a change in preference. An example of this is Hepburn's and Ross sedges which did not occur on any of the plots on the sedimentary soils.

Species other than those listed in table 7 did occur on the sheep range and some of them had even a higher preference than those listed. Such species occurred only on one of the two sites sampled on the granitic or sedimentary soils or they occurred so infrequently or contributed so little to the total herbage production they were not included in the table. Species of this category occurring on the granitic soil included alpine timothy, water and Eastwood sedges, and lambstongue groundsel. On the sedimentary soils, silky lupine, little larkspur, sticky geranium, timber oatgrass, and Letterman needlegrass were high in preference but relatively infrequent and negligible as herbage producers on the sampled areas. In contrast to this, Idaho fescue produced 33 percent of the total herbage production and occurred on every sample plot on the granitic soils, but of the 36 species which occurred on the plots it ranked 35th in preference. Other species on granitic soils having low preference included pussytoes and ballhead sandwort; these two forbs and Idaho fescue produced about half of the total herbage production. Similarly, on the sedimentary soils Idaho fescue was a high producer -- 24 percent of total herbage -- but extremely low in preference. As also was found on the cattle ranges, some of the most abundant species which generally produced the greatest amount of herbage were often the least preferred by the class of livestock grazing the range.

Game: Information on preference shown by deer and perhaps elk was obtained largely through observation and limited sampling in livestock-proof exclosures. These data, although incomplete, do indicate that deer graze leaves and flowers of mountain dandelion and splitleaf paintedcup, and the flower stems and heads of hoary balsamroot and diamondleaf saxifrage. In a stockproof exclosure, deer had consistently grazed common dandelion, Kentucky bluegrass, and alpine timothy and, to a lesser extent, water sedge and yarrow. Already mentioned is the observation of deer grazing willows from July through September. In an area ungrazed by livestock, use by either deer or elk or both was seen on spike fescue, serviceberry, rose, and shrubby cinquefoil.

An indication of use on the range during part of the livestock grazing was obtained on two areas of the Buffalo District. Pellet-group counts were made approximately July 25 and again at the close of the grazing season -- September 30. The increase in number of pellet groups during this period can be used as an index to the use being made of the range by game concurrent with livestock use. Using 12.7 pellet groups as an indication of a day's grazing by deer (11) and elk, the use on the sampled area in the Clear Creek Allotment was 0.5 elk days per acre per month during the period from July 27 to October 4. Use from July 21 to September 19 on the sampled portion of the Muddy Creek Allotment amounted to 0.9 deer days and 1.1 elk days per acre per month. The representativeness of these two areas with respect to game use is not known but they are important as cattle range.

Plant growth and development

Total precipitation for the period of observation as well as the amount received between observations is given in table 8. As indicated here, there was generally a decrease in precipitation as the summer season progressed with the minimum usually occurring in the August 10-22 period at all stations. There was no clear indication that precipitation increased with an increase in elevation nor were equal amounts received at the two 8000 stations. These two stations, although both on the east side of the main divide of the Big Horn Mountains, are approximately 40 air-line miles apart. This, as well as the differences between the 7200 and 8000 stations both on the Buffalo District, and between the 8000 and 8500 stations on the Tongue District suggest that summer storms may be rather local, of various intensities, or both. Also it indicates that the 8000 stations on the Tongue District may lie in the path followed by summer storms. However, since records are available for only 1 season, any interpretations of precipitation patterns are indeed questionable.

Whether the precipitation during the 1951 grazing season was above or below the average for the entire Forest is not known. Precipitation at Hunter Ranger Station (7,400 feet) on the Buffalo District as reported by the U. S. Weather Bureau (19) was 32 and 56 percent above average for June and July, respectively. August precipitation here was 43 percent below average and no record is available for September. The 7200 station is within 2 miles of the Ranger Station and in the same local drainage area. Other Weather Bureau stations to the east of the mountains (Sheridan, Buffalo, and Metz Ranch) all had above-normal precipitation for June, July, and September, while a deficit occurred at two of the stations during August. For the 4-month period, June through September, the precipitation at these three stations averaged 44 percent above normal.

Measurements and observations were made on from four to six species at each plant-development station at 2-week intervals starting about July 1 and

extending throughout the growing season. Average maximum heights were determined for each of the observed species, the stage of development was recorded, and production was estimated. Since Idaho fescue, Sandberg bluegrass, and big bluegrass are of primary importance as forage producers on the cattle ranges and because they occur so widely, they will be the only species given detailed consideration here.

When measurements were started on June 29 at the 7200 and 8000 stations on the granitic soils of the Buffalo District (fig. 7), growth of the grasses was well under way. For example, at both stations, basal leaves of Idaho fescue had reached their maximum length, from 50 to 75 percent of the total plant height had been made, and approximately 60 percent of the production had been attained. At the 7200 station the heads of Idaho fescue were completely out of the boot while at the 8000 station, heads were breaking out of the boot. At this time silky lupine, American bistort, and mountain dandelion were in full bloom. About June 2[illegible] cattle came on the allotments where the plant-development stations were located.

The 8000 and 8500 stations on the Tongue District were both located on soils derived from the shales, sandstones, and limestones of the Deadwood formation. At the time the first measurements were made at these stations -- July 3 -- basal leaves of Idaho fescue had reached 90 percent of their maximum length, 34 percent of maximum plant height had been attained, and an estimated 42 percent of the production was present. At the 8000 station, heads were starting to break out of the boot whereas no heads were visible at the 8500 station. Although the development of Idaho fescue at these two stations was behind that on the Buffalo District, the basal leaf length was longer -- 5.0 inches compared to 7.8 inches. Those forbs which were in full bloom on June 29 at the two Buffalo District stations (7200 and 8000) were in bud at the Tongue stations (8000 and 8500) on July 3 and would be in full bloom on July 16. June 29 was the average entrance date for cattle on the two Tongue District Allotments where the plant-development stations were located.

First measurements were made at the 9300 station (granitic soils) and 9500 station (sedimentary soils -- Deadwood formation) on July 17 and 18. At this time sheep had been on the adjacent portions of the two allotments for 7 to 10 days. At both stations the heads of Idaho fescue were out of the boot although a greater portion of total height (57 percent) had been attained at the 9300 station at this time. Common dandelion, alpine forget-me-not, and shooting-star which were in full bloom had been in full bloom 2 weeks earlier at the 8000 and 8500 stations on the Tongue District.

Maximum height growth for Idaho fescue and Sandberg and big bluegrasses was reached during the flowering stage. This association was true at all stations where these grasses occurred. At both the 7200 and 8000 stations on the granitic soils of the Buffalo District, Idaho fescue reached its maximum height by July 30 as did Sandberg bluegrass at the 8000 station. Height growth was practically completed for both of these grasses 2 weeks later at the other four stations. This date usually coincides with the period receiving the least amount of precipitation (table 8). At the same time that maximum heights were reached at all stations, yarrow was in full bloom.

Growth rates of Idaho fescue and Sandberg and big bluegrasses as well as average maximum heights are presented in fig. 8. As seen here, the three grasses reached their maximum height at the 8000 station on the Tongue District. Both Idaho fescue and Sandberg bluegrass were taller at the three stations located on the sedimentary soils -- 8000 Tongue, 8500, and 9500. As previously shown, the 8000 station on the Tongue District received the greatest amount of precipitation

Table 8.--Dates and length of record and precipitation received at six plant-development stations in 1951

Station	Date of record	Length of record (days)	Total precipitation (inches)	Precipitation by periods[1] (inches) and percent of total											
				6/27-7/13		7/14-7/24		7/25-8/9		8/10-8/22		8/23-9/18		9/19-10/4	
				in.	%	in.	%	in.	%	in.	%	in.	%	in.	%
7200	6/27-10/4	99	6.20	2.35	39	1.23	20	0.60	9	0.22	3	0.79	13	1.01	16
8000 (Buffalo District)	6/28-10/5	99	5.22	1.92	37	0.55	11	0.12	2	0.32	6	0.99	19	1.32	25
8000 (Tongue District)	6/27-10/2	97	7.07	1.91	27	0.90	13	1.10	15	0.64	9	1.32	19	1.20	17
8500	6/26-9/29	95	5.56	1.42	26	1.15	21	0.78	14	0.57	10	1.02	18	0.62	11
9300	7/ 6-9/14	70	4.26	0.92	21	1.71	40	0.72	17	0.03	1	0.88	21	----	--
9500	7/ 9-9/14	67	4.63	0.82	18	0.78	17	1.75	38	0.50	10	0.78	17	----	--

1/ Dates of periods are averages and do not always indicate the exact period when precipitation was received.

during the measurement period. However, the precipitation at the 7200 station (granitic soils) exceeded that at the 8500 station where Idaho fescue was about 3.5 inches taller. Inherent productivity of soils as well as the apparently more favorable moisture-holding capacity of the sedimentary group derived from the Deadwood formation probably accounts for the taller plants and for a greater volume of herbage production per acre (table 2). There was no observable difference in the soil at the 8000 Tongue, 8500, and 9500 stations, although the grasses were always shorter at the highest elevations. The same was true for slender wheatgrass at these three stations.

Although the grasses at the 9500 station, for example, were not as far advanced as at either of the other two stations on sedimentary soils for any of the earlier dates they usually reached the "flowering completed" stage and maximum height at the same time. Rate of growth, and particularly development, at least to the flowering stage, at the higher elevation was usually greater than at the lower elevations; Costello and Price (3) had found the same response by grasses in central Utah.

Both Sandberg and big bluegrasses had made some fall regrowth at the end of the grazing season. For Sandberg bluegrass this varied from 1/4 to 1 inch with the greatest height on the sedimentary soils. Big bluegrass fall growth was as much as 5.5 inches at the 8000 station and 2 inches at the 9500 station; for both grasses the regrowth was limited to a few blades per plant. No fall regrowth was definitely associated with Idaho fescue at any of the stations and the grass had a dry appearance. At all stations green basal leaves were found in the interior of the fescue plants but the appearance suggested a protective position from frosts rather than new fall growth.

Moisture content of Idaho fescue for any given date, with but one exception, was lower in the samples collected from granitic soils regardless of elevation. On June 29 samples collected at 7200 and 8000 stations on the Buffalo granitic soils both had an average moisture content of 55 percent. The lowest moisture content was 31 percent for a sample collected at the 9300 station (granitic soils) on August 28, the last sampling date. In contrast to this, the samples from sedimentary soils averaged 64 percent moisture on the first sampling date -- July 3 -- and moisture content was 54 percent on August 28. Sandberg bluegrass followed much the same pattern ranging in moisture content from 65 to 27 percent on granitic soils and from 79 to 33 percent on sedimentary soils. The greater moisture content of the forage grasses growing on the sedimentary soils may have some influence on palatability and in turn tend to promote better cattle distribution on such soils.

SUMMARY

During the summer of 1951 a research program was initiated on the Bighorn National Forest in north central Wyoming, to obtain information to aid in the management of these and similar livestock ranges. The Bighorn National Forest is entirely within the Bighorn Mountains, although they extend north and south of the Forest. Geology of this mountainous uplift consists of granites capped by various sedimentary formations, the oldest being the shales, sandstones, and limestones of the Deadwood formation of the Cambrian system. In many areas, the sedimentary formations have been eroded completely away, leaving the gray and red granites to characterize the landscape. In some areas, particularly on the Buffalo District, granitic deposits of preglacial age occur and are customarily associated with a grass-type vegetation.

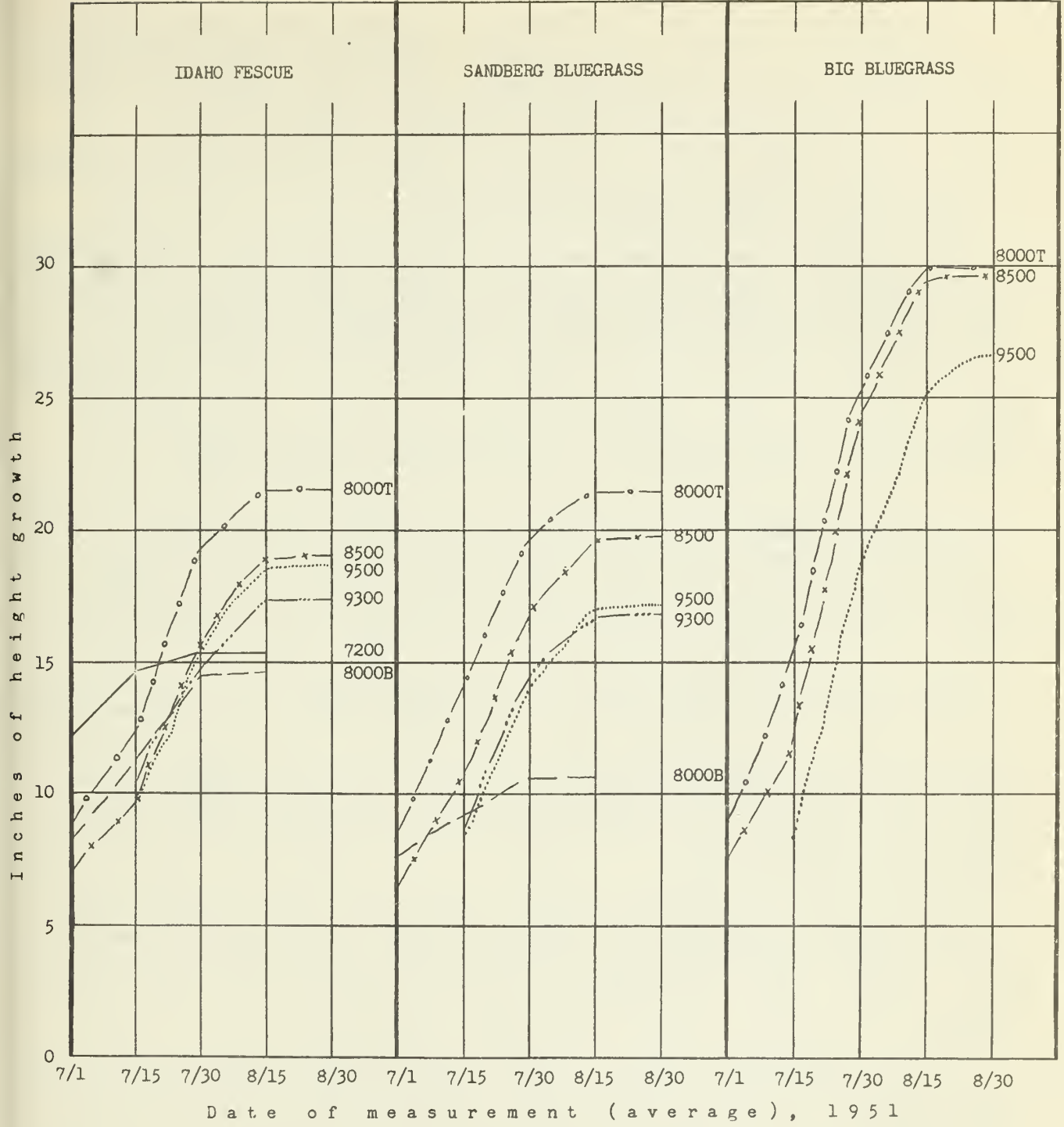

Figure 8.--Growth of three grasses at plant-development stations; granitic soils at 7200, 8000B, and 9300, and sedimentary soils at other stations.

The formation of soils in this humid or subhumid mountain area has been strongly influenced by the kind of vegetation. Beneath the coniferous forests, largely lodgepole pine, are found the Podzolic soils whereas black acid Prairie soils are found under the grass-forb cover. Of particular significance on the Forest is the large area in parks, many of which are completely treeless and, except for the shrubby willows and occasional patches of shrubby cinquefoil, are often brushfree. These parks are particularly important as livestock ranges and support a wide variety of grasses and forbs.

Data obtained from transects which sampled portions of the upland vegetation on the cattle ranges of the Tongue and Buffalo Districts show that Idaho fescue, Sandberg bluegrass, needleleaf sedge, prairiesmoke sieversia, and starry cerastium were common on both the granitic- and sedimentary-derived soils. Also, some species such as little club moss and pussytoes are much more frequent and constitute a greater part of the vegetative cover on the apparently droughtier granitic soils than on the sedimentary soils. In contrast, big bluegrass and northern bedstraw which were commonly associated with the vegetative cover on sedimentary soils were infrequently encountered on the granitic soils.

Total herbage production was greater on the sedimentary soils largely due to the greater abundance and productivity of such forbs as silky lupine, prairiesmoke sieversia, and yarrow. Grass production was found to be greater on the granitic soils of the grazed cattle ranges due largely to the greater abundance of Idaho fescue. The relationship of forbs to grass shifted in favor of grass on lightly grazed or protected areas occurring on sedimentary soils.

Both cattle and sheep were found to be highly selective in their foraging. Prairiesmoke sieversia, silky lupine, and needleleaf sedge, although often abundant, were not grazed to any extent by cattle, whereas Idaho fescue and Sandberg and big bluegrasses were grazed readily and furnished most of the forage. In contrast, Idaho fescue was practically unused by sheep and accounted for a greater percent of the herbage production than any other species on the sampled sheep ranges. Prairiesmoke sieversia, lupine, and yarrow as well as some other forbs unused by cattle were grazed by sheep.

Precipitation data during the field season were obtained at six plant-development stations ranging in elevation from 7,200 to 9,500 feet. Lack of data for previous years did not permit direct comparison for the 1951 grazing season, although three Weather Bureau stations to the east of the Forest averaged 44 percent above normal for the June-through-September period.

At the time grazing started on the allotments where the plant-development stations were located, basal leaves of Idaho fescue had nearly reached their maximum length at all stations and from 35 to 50 percent and even more of the average maximum plant height had been obtained. Maximum heights for Idaho fescue and Sandberg and big bluegrasses occurred during the flowering period at all six stations. This period was reached 2 weeks earlier at those stations on the granitic soils at the lower elevations. Both Idaho fescue and Sandberg bluegrass were taller when growing on the sedimentary soils.

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APPENDIX

Geology

The geology of the Big Horn Mountains has been reported in detail by Darton (4,5,6). He points out that the rocks uplifted in the Big Horn Mountains comprise red and gray granites covered by sedimentary layers of various thicknesses. These layers consist mainly of sandstones, limestones, shales, sand, and gravels, all presenting more or less variety in composition and appearance. The principal materials of which they are composed were originally gravel, sand, or mud derived from the waste of older rocks, or chemical precipitates from salty waters.

Darton (6) describes the central area of the higher portion of the mountains as a region of rugged ridges rising toward the main divide along the center of the uplift. The higher portions of this central area exhibit strong erosion, due largely to the intensity of frost action, the steep slopes, and the abundance of water to carry off the debris. The granite floor on which the sedimentary rocks were deposited has been exposed, the sedimentary rocks entirely cut away by erosion. The higher region has been extensively glaciated, most of its topographic features being characteristic of glacial erosion. Accumulation of glacial deposits occur in the lower valleys of the central area, impeding the drainage and giving rise to many small lakes. Other lakes occur in rock basins excavated in granite in connection with glaciation. The timber line is at an altitude of about 9,500 feet, above which the surface consists mainly of rock masses in part disrupted from their original ledges.

The sedimentary rocks arch over the northern and south central portions of the Big Horn Mountains, forming an elevated plateau which has an altitude of about 9,000 feet in the north and 8,000 feet in the south (6). It presents broad areas of tabular surfaces, especially near the divides, but is deeply trenched by numerous canyons, the most notable occurring on the Forest are those of the Little Big Horn and Tongue Rivers. Much of the plateau surface is covered by forests interspersed with parks. Portions of the plateau also extend northward and southward partly encompassing the central granite area and the termination of the uplift.

The three most extensive sedimentary formations occurring on the Forest are the Deadwood, Bighorn, and Madison. The Deadwood contains the oldest sedimentary rocks found in the Big Horn Mountains; above this is the Bighorn limestone and upon this rests the Madison limestone. The surface of much of the higher portions of the northern part of the Big Horn Mountains consists of sandstones and shales of the Deadwood formation, which lie directly on the granite rocks (6). The formation has in most places a thickness of about 900 feet and, owing to the preponderance of soft materials, weathers in long, rounded slopes. Bald Mountain which rises as a huge rounded mound 800 feet above a platform of granite, is the most notable example of this feature. Little Bald and Cone Mountains are similar but smaller examples. Sheep, Medicine, Duncum, and Hunt Mountains have long slopes of Deadwood beds capped by Bighorn limestone. The Walker Prairie on the Goose District of the Forest is another example of the Deadwood formation, as are the long slopes of the valleys of Tongue River, and Cedar, Shell, and Granite Creeks.

Probably the most conspicuous sedimentary formation is the hard, massive Bighorn limestone which rests on the Deadwood formation and outcrops in huge ledges surmounting the long slopes of Deadwood rocks (6). Owing to the softness of the underlying Deadwood shales and the hard massive nature of the Bighorn limestone, the latter gives rise to high cliffs with a talus of huge blocks of limestone on the slopes below.

The greater part of the high front ridges flanking the Bighorn uplift consists of a thick mass of limestone designated as the Madison formation (6). Beginning at Little Goose Creek, the outcrop of the formation extends northwestward in a zone varying in width from 1 to 2 miles in greater part. North of the Tongue River the formation is spread out widely in sloping ridges and plateaus, but it has been extensively removed over the crest of the ridges along Sheep Creek and about Freezout Point. About the headwaters of Tongue River, and especially to the south of that valley, the formation caps the plateaus which here constitute the summit of the main range. This plateau is wide between Tongue River and Cedar Creek where the beds lie nearly horizontal over an area of about 30 square miles. Along Shell Creek the formation has been widely removed and its edge presents high cliffs on the south side of that valley. From these cliffs a thick sheet of the limestone slopes gently downward to the south and west, where it is deeply cut by White and Trapper Creeks.

Along the sides of the Big Horn Mountains there are steep slopes to the plains on the east and the Big Horn Basin on the west. In some places the central plateau terminates in high cliffs, but in other areas, especially along the eastern side of the range, there is a distinct flanking ridge of rim rock. The front range is composed of sedimentary rocks dipping steeply to the northeast and east and it usually presents to the west a high cliff of limestone. Through this front range the creeks and rivers which rise in the central area find their way out to the plains in canyons, some having walls nearly 2,000 feet high. The most notable are those of the Little Big Horn and Tongue Rivers on the east side and Shell, Paintrock, and Tensleep Creeks on the west side.

Within the boundaries of the Bighorn National Forest much of the Medicine Wheel District, approximately two-thirds of the Tongue District, and perhaps one-fifth of the Paintrock District are characterized by the sedimentary formations of the central plateau area. The remaining three districts of the Forest -- Tensleep, Buffalo, Goose -- are largely composed of granite or granitic material. Glacial deposits cover considerable area in all three districts and active glaciation has changed the land surface. Also deposits of an earlier age are found principally on the Buffalo District. These deposits of sands, volcanic ash, gravel, and boulders are associated with the plains-like topography north and east of Hazelton and the main divide between the heads of North Fork of Powder River and Canyon Creek at an altitude from 8,700 to 9,100 feet. Similar areas are found at Elgin Park and Hunter Mesa.

Soils

Two important groups of soils are represented in the Big Horn Mountains developed under identical climatic conditions but under entirely different vegetative covers (16). These two groups are the black acid Prairie soils developed under herbaceous vegetation and the Podzolic soils found in the timbered areas. In the soil surveys of Sheridan and Johnson Counties, Wyoming (7,16), which include the eastern half of the Bighorn National Forest,

the grassland and forested soils have been broadly classified and described. The general characteristics, if not the detailed descriptions, undoubtedly extend to the remainder of the Forest.

The grassland soils derived from decomposed granite, glacial, and alluvial granitic debris have been named Burgess loams or fine gravelly loams (7,16). In most instances these soils rest on granite rocks and because of the prevalence of granite, these soils are widespread. The alluvial granitic deposits found in the Hazelton, Elgin Park, Canyon Creek, and Hunter Mesa areas are examples of the Burgess loam grassland soil. Characteristically, these grassland soils have a 6-inch layer of dark brown or nearly black loam underlain by yellowish-brown acid loam which in some places is thin and overlies solid rock and in other places may be 9 to 10 inches thick. Outcrops of pink or gray granite are numerous in some areas and large boulders are scattered over the surfaces in others, indicating past influence of glaciation.

The grassland soils from the sedimentary rocks are derived from sandstones, limestones, and shales. Where the topography is favorable, these soils have attained good depth but on the steep slopes the dark-brown or black silt loam layer 1 to 6 inches thick may pass directly into decomposed limestone. In other places there may be a 3- to 4-inch yellowish-brown layer above the parent limestone. Soils of greater depth such as those in the Willow Creek and Owen Creek series are black or very dark brown friable silt loam to 12 to 14 inches. Below this is a yellowish-brown, silty clay loam of 3 to 14 inches thick, underlain by greenish-yellow plastic clay to a depth of 48 inches or more for the Owen Creek series and a yellow silt loam from 30 to 50 inches for the Willow Creek series. According to the descriptions for the Sheridan County soil survey (16), the Owen Creek series is derived from schists, but no evidence of this was seen and instead shales and other sedimentary rocks were found at the lower depths. Generally the soils from the sedimentary rocks support a more luxuriant herbaceous cover than those having granitic origin (7,16).

The forest soils, like the grassland soils, occur on both the granitic material and the sedimentary formations. The Woodrock series characterizes the soils derived from granitic material and developed for the most part under lodgepole pine. This soil is light grayish-brown loam to a depth of 3 or 4 inches; below this the soil is lighter, sometimes an ash gray for about 10 inches and underlain by an 8-inch layer of brownish-yellow gravelly clay loam containing rock fragments of the granite or granitic sandstone, whichever form the underlying bedrock (16). The forested sedimentary soils are all similar to the granitic soils in depth and color in the upper layer but are usually yellowish-brown below having an alkaline or neutral reaction and having sandstone or limestone as parent material. Although lodgepole pine, Engelmann spruce, and alpine fir are reported occurring on all soils regardless of parent material, there appears to be a tendency for spruce and fir to be more abundant on alluvial and sedimentary soils. Limited observations suggest that limber pine occurs largely on limestone soils and characteristically on ridges where the soil is thin.

Much of the Forest has been designated by the Sheridan County survey as rough mountainous land and this includes steep canyons and mountains most of which are too steep or too rocky or both, for use by domestic livestock (16). This land often supports a good growth of timber in some places and is an excellent habitat for game.

Climate

A belt of relatively high precipitation coincides with the high elevation of the mountain area and the accompanying lower air temperatures aid in the creation of a humid or subhumid climate. For example, the average annual precipitation for Dome Lake, elevation 8,821 feet, is 27.10 inches with the mean July temperature being 55.4° (19) (table 9). At Hunter Ranger Station, 7,400 feet elevation, and approximately 25 air-line miles distant on the same side (east) of the Divide, the average annual precipitation is 19.01 inches, the mean temperature for July is 58.0°. Descending in elevation toward the east, the weather stations at Sheridan, Buffalo, and Metz Ranch have an averaged annual precipitation of 13.60 inches; averaged mean July temperature is 68.4°. These three stations have an average elevation of 4,649 feet and are located approximately 10 miles east from the base of the mountains (6,000-foot contour). In the Big Horn Basin to the west of the mountains the average annual precipitation for Lovell, Hyattville, and Tensleep was 7.69 inches and the mean July temperature was 72.3° (19). The stations average approximately 11 miles west of the 6,000-foot contour on the Big Horn Mountains; the average elevation for the three stations is 5,050 feet.

As seen in table 9, from 70 to 75 percent of the precipitation received at the lower elevation occurs during the 6-month period April through September when temperatures are favorable for plant growth. At Hunter Ranger Station 57 percent of the annual precipitation occurs in the May-through-September period, while at Dome Lake 31 percent falls during the June-through-September period. The prevailing lower temperature in the mountains and the protection from winds given to a large part of the mountain slopes by relief and by forests, reduces evaporation and maintains the humidity of the soil to a greater degree than would be expected from the amount of precipitation received during the growing season (16). This tends to prolong the growth of the herbaceous vegetation.

Vegetation

The Bighorn National Forest is characterized by large and frequent parks rimmed by stands of lodgepole pine. This was recognized and reported by Williams in 1897 (20) and thought to be of particular significance by other early investigators (6,9,17). Both Town (17) and Jack (9) estimated that the Forest is divided about equally between timbered and untimbered areas. Jack (9) divided the openings or parks into two classes: "those bordering streams and interspersed among belts and groves of timber, and those which are situated upon high slopes or practically above timber line." The part of the Forest east of the main divide is much more closely covered with tree growth than on the western side where the timber often appears in islandlike groups or small areas or belts in the midst of the park or open area (9). The timber is most frequent and best developed on north and east slopes.

In addition to their prevalence at high altitudes the open or park areas occur in all parts of the Forest. In the northern part, these parks are usually covered with short-grasses and sedges of numerous species and other dwarf herbage but without much shrubby vegetation (9). On the south slopes big sagebrush covers large areas and in the southern part of the Forest, particularly on the western side of the main divide, it is much more abundant on many slopes.

Table 9.--Average monthly and annual precipitation and temperature for Big Horn Mountain and adjacent stations

Month	Weather stations and elevations							
	Dome Lake 1/ (8,821 feet)		Hunter R.S. 1/ (7,400 feet)		East side 1/2/ (4,649 feet) 3/		West side 1/2/ (5,050 feet) 4/	
	Precip.	Temp.	Precip.	Temp.	Precip.	Temp.	Precip.	Temp.
	inches	°F.	inches	°F.	inches	°F.	inches	°F.
January	1.67	14.5	0.72	18.1	0.60	21.2	0.47	19.1
February	1.51	15.9	0.64	19.4	0.53	24.0	0.30	22.8
March	2.90	20.9	1.40	23.8	0.95	33.1	0.53	34.0
April	3.74	29.2	2.39	33.0	1.70	43.0	0.83	45.6
May	3.59	37.2	3.10	41.6	2.46	51.7	1.12	55.9
June	2.66	47.1	2.42	50.1	1.98	61.0	0.99	65.3
July	2.06	54.0	1.95	57.4	1.23	68.4	0.61	72.3
August	1.76	52.5	1.57	55.7	1.00	66.7	0.50	69.8
September	2.00	44.0	1.54	47.6	1.20	56.3	0.72	59.0
October	2.23	34.0	1.50	38.4	0.86	45.6	0.83	47.0
November	1.47	24.9	0.62	28.8	0.53	33.9	0.39	33.0
December	1.51	16.4	0.58	21.4	0.56	24.5	0.40	21.8
Annual average	27.10	32.6	18.53	36.3	13.60	44.1	7.69	45.5

1/ See References Cited (19).
2/ See References Cited (18).
3/ Average for Sheridan, Buffalo, and Metz Ranch; length of record ranged from 31 to 56 years; average distance east from base of mountains (6,000-foot contour) is 10 miles.
4/ Average for Lovell, Hyattville, and Tensleep; length of record ranges from 16 to 41 years; average distance west from base of mountains (6,000-foot contour) is 11 miles.

The report by Jack (9) is more specific regarding vegetation on what is now the Bighorn National Forest than are any of the available earlier reports. He mentions that "of the numerous species of grasses distributed throughout the reserve there is probably none so universal and characteristic in all sorts of situations as the so-called sheep's fescue. ...It is found from the lower levels of the reserve up to 11,000 or 12,000 feet altitude or as high as sheep or cattle can be driven for grazing. It occurs scattered among other grasses and the herbaceous vegetation locally called weeds, usually in small isolated tough bunches or tufts rarely close enough together to cover the ground with its own species on patches more than a few feet square." Today this fescue, now believed to be Idaho fescue, is still an important part of the herbaceous vegetation. Perhaps next as forage plants are the bluegrasses which, for the most part, are of the bunch type. Other grasses include the bromes, wheatgrasses, oatgrasses, and tufted hairgrass. The last in combination with various species of sedges form much of the herbaceous cover in the more moist and poorly drained areas.

Growing with these grasses are usually a great variety and abundance of forbs (weeds) especially in the deep, moist soils having sedimentary parent material. Most prominent, although there is considerable variation with the

progress of the growing season, are prairiesmoke sieversia, lupines, mountain dandelions, yarrow, cinquefoils, starry cerastium, and phlox. On thinner soils and drier sites the weeds and grasses are sparser and shorter and at the higher elevations in particular such forbs as pussytoes and phlox are more prominent. On granitic soils the forbs are much less conspicuous although present, and little club moss appears as a frequent and abundant mat-forming species. In the timbered areas the herbaceous vegetation is greatly reduced, particularly where the stands are dense, and where more open many of the same species occur as found in the openings. Some of the shade-tolerant plants such as lupine, heartleaf arnica, and Wheeler and nodding bluegrasses are characteristically found in timbered areas. The most abundant plant beneath the lodgepole pine is the low-growing huckleberry which usually grows a few inches in height, but forms a close ground cover beneath the trees. It spreads freely by suckers and forms a good protective covering to humus and soil (10).

The most conspicuous shrub on the Forest is probably big sagebrush which occurs particularly on the drier and exposed slopes to 10,000 feet. On the banks of streams, covering boggy areas, and growing on moist slopes are often large patches or fields of shrubby willows, and occasionally bog birch. In some places, usually more moist than the typical big sagebrush site and drier than the typical willow site, shrubby cinquefoil often appears; however, it is fairly local. Other shrubs such as rose, buffaloberry, gooseberry, ninebark and mountain mahogany do appear locally. In general, and except for big sagebrush and willow, the shrubby vegetation is not conspicuous.

Lodgepole pine is the most abundant tree on the Forest, being generally found at all elevations so that there are very few timbered areas where it does not occur (9,17). Ranking second in abundance is Engelmann spruce which is most often found in cool moist situations such as along stream bottoms, mountain sides where springs occur, and on north slopes. Compared to lodgepole pine, this spruce occupies but a very small proportion of the total forested area (9,17). Alpine fir, Douglas fir, and ponderosa pine are also present in limited amounts, the last being generally below the Forest boundary. Occurring locally are juniper, particularly on the west side of the divide, limber pine usually on the limestone ridges and outcrops, and scattered patches of aspen. Altogether there are 10 species of trees found on the Forest (17) and lodgepole is by far the most common species.

Darton (5) mentions that tree growth is sparse or absent from the greater portion of the Deadwood shales and Bighorn limestone formations. Furthermore, that owing to the softness and possibly in part to its chemical composition, the Deadwood shales are unfavorable to forest growth, and slopes of the Deadwood formation are usually bare of trees (4). Town (17) believed that at one time trees covered all the park areas but that successive fires destroyed the timber. Jack (9) also thought fires were influential in the formation of parks and that perhaps game contributed toward preventing the spread of timber in some areas.

Lodgepole pine and Engelmann spruce are being cut for lumber and also for poles and posts. In addition, lodgepole pine is being cut on a limited scale for pulpwood. Town (17) in his report in 1898 was not enthusiastic about the timber production in the Bighorn National Forest, particularly its qualities, largely because he thought lodgepole pine an inferior lumber tree. However, he pointed out the importance of this forest cover as being "useful in holding

the snow and retarding the flow of water" since "these people depend upon these mountains for irrigation water." Much the same point of view was held by Jack (9): "The preservation and maintenance of their (ranchmen, farmers, townspeople) water supply is a desideratum which should be looked upon as paramount to all other local consideration." Williams (20) in 1897, also mentioned the importance of the forest cover to water for irrigation and the necessity of protecting the forests from fire. Thorp et al (16) state that "one of the most important benefits occurring to the ranchers of the county (Sheridan) from the forested lands of the Big Horn Mountains is the supply of pure water they furnish for domestic and irrigation purposes. The forest holds in check the melting of the heavy snowfall, so the water supply from this source extends well into the summer. Without the forest cover, the snow would disappear much earlier, and many of the streams would become dry before the end of the growing season."

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SCIENTIFIC AND COMMON NAMES OF PLANTS MENTIONED

Scientific Name	Common Name[1/]
GRASS AND GRASSLIKE	
Agropyron dasystachyum	Thickspike wheatgrass
" spicatum	Bluebunch wheatgrass
" subsecundum	Bearded wheatgrass
" trachycaulum	Slender wheatgrass
" spp.	Wheatgrass
Agrostis idahoensis	Idaho bentgrass
Bromus pumpellianus	Pumpelly brome
" spp.	Brome
Danthonia intermedia	Timber oatgrass
" spp.	Danthonia
Deschampsia caespitosa	Tufted hairgrass
Festuca idahoensis	Idaho fescue
" ovina	Sheep fescue
Hesperochloa kingii	Spike fescue
Koeleria cristata	Prairie junegrass
Phleum alpinum	Alpine timothy
Poa ampla	Big bluegrass
" nervosa	Wheeler bluegrass
" pratensis	Kentucky bluegrass
" reflexa	Nodding bluegrass
" secunda	Sandberg bluegrass
" spp.	Bluegrass
Stipa comata	Needle-and-thread
" lettermani	Letterman needlegrass
" spp.	Needlegrass
Carex aquatilis	Water sedge
" eastwoodiana	Eastwood sedge
" eleocharis	Needleleaf sedge
" hepburnii	Hepburn's sedge
" rossii	Ross sedge
" spp.	Sedge
Juncus confusus	Rush
Luzula spicata	Spike woodrush
FORBS	
Achillea lanulosa	Yarrow
Agoseris spp.	Mountain dandelion
Allium spp.	Wild onion
Antennaria rosea and A. reflexa	Pussytoes
Arenaria congesta	Ballhead sandwort
Arnica cordifolia	Heartleaf arnica
" fulgens	Orange arnica
Aster spp.	Aster
Astragalus striatus	Prairie milkvetch
Balsamorrhiza incana	Hoary balsamroot

1/ Generally based on Standardized Plant Names, 2nd Edition.

FORBS (continued)

Calochortus sp.	Mariposa lily
Campanula rotundifolia	Bluebell
Castilleja rhexifolia	Splitleaf paintedcup
Cerastium arvense	Starry cerastium
Chrysopsis villosa	Hairy goldaster
Collinsia parviflora	Littleflower collinsia
Delphinium bicolor	Little larkspur
Dodecatheon conjugens	Shootingstar
Galium boreale	Northern bedstraw
Geranium viscosissimum	Sticky geranium
Geum triflorum (Sieversia ciliata)	Prairiesmoke sieversia
Gilia linearis	Slenderleaf gilia
Lupinus (sericeus?)	Silky lupine
Myosotis alpestris	Alpine forget-me-not
Phlox hoodii	Hoods phlox
" multiflora	Flowery phlox
" spp.	Phlox
Polygonum bistortoides	American bistort
Potentilla glaucophylla	Blueleaf cinquefoil
" spp. (herbaceous)	Cinquefoil
Ranunculus spp.	Buttercup
Saxifraga rhomboidea	Diamondleaf saxifrage
Senecio integerrimus	Lambstongue groundsel
Taraxacum officinale	Common dandelion

MOSSLIKE

Selaginella densa	Little club moss

SHRUBS AND TREES

Abies lasiocarpa	Alpine fir
Amelanchier spp.	Serviceberry
Artemisia frigida	Fringed sagebrush
" tridentata	Big sagebrush
Betula glandulosa	Bog birch
Cercocarpus spp.	Mountain mahogany
Juniperus scopulorum	Rocky Mountain juniper
Physocarpus spp.	Ninebark
Picea engelmanni	Engelmann spruce
Pinus contorta latifolia	Lodgepole pine
" flexilis	Limber pine
" ponderosa	Ponderosa pine
Populus tremuloides	Aspen
Potentilla fruticosa	Shrubby cinquefoil
Pseudotsuga taxifolia	Douglas fir
Ribes spp.	Gooseberry
Rosa spp.	Rose
Salix spp.	Willow
Shepherdia spp.	Buffaloberry
Vaccinium scoparium	Huckleberry

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